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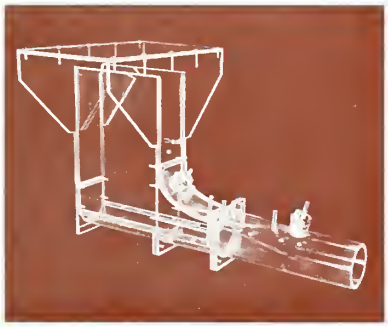
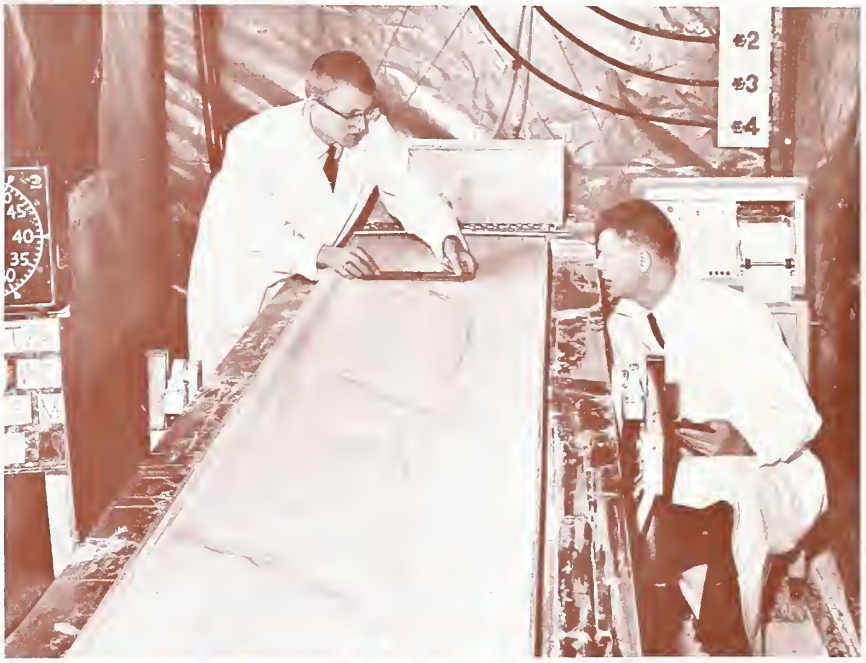
Soil and Water Conservation Research in the Corn Belt States

U.S. DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE





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Locations where soil and water conservation research is being conducted in the Corn Belt by the Agricultural Research Service, U.S. Department of Agriculture.

(Letters in parentheses refer to contents section that indicates the nature of research under way at that location.)

Ames, Iowa (E, J, H)

Council Bluffs, Iowa (Substation of Columbia, Mo.) (A, B, C, G)

Lafayette, Ind. (C)

Lincoln, Neb. (G, I)

Madison, S. Dak. (Substation of Morris, Minn.) (C, I)

Manhattan, Kans. (C)

Minneapolis, Minn. (D)

North Appalachian Experimental Watershed, Coshocton, Ohio (A, C, F, G)

North Central Soil Conservation Research Center Morris, Minn. (C, F, G, H, I, J)

Northern Great Plains Research Center Mandan, N. Dak. (F, G, I)

St. Paul, Minn. (G, H)

Urbana, Ill. (J)

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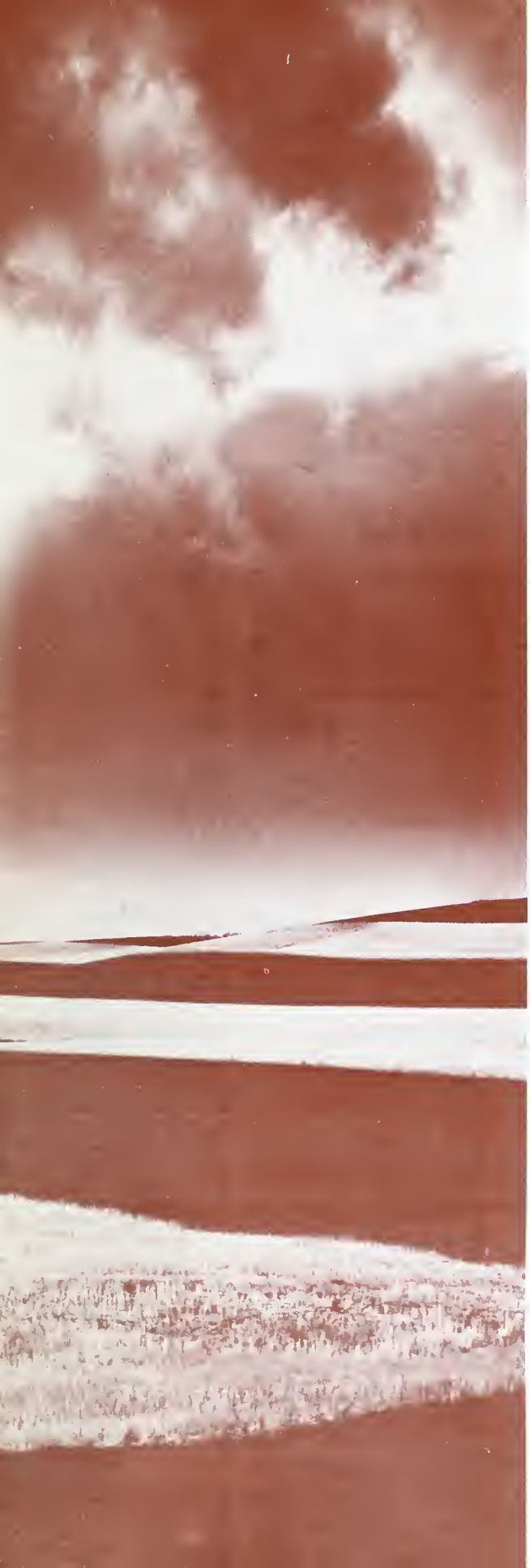
July 1974

From birth to death, natural resources, transformed for human use, feed, clothe, shelter, and transport us. Upon them we depend for every material necessity, comfort, convenience, and protection in our lives. Without abundant resources, prosperity is out of reach. Therefore, the conservation of natural resources is the fundamental material problem.—Gifford Pinchot (SCS photo)



Soil and Water Conservation Research in the Corn Belt States

By Thomas J. Thiel, *program analyst, North Central Region, Agricultural Research Service, U.S. Department of Agriculture*

Soil and water are the Nation's most fundamental natural resources. All Americans are vitally dependent upon these resources for the essentials of human existence—food, clothing, shelter, and a place to live. Orderly and wise development and conservation of these resources depend on the efforts and interest of everyone.

Water and soil first interact when rain falls on the earth's surface; most of this occurs on agricultural land and forests. Management practices developed through research and applied to the soil can enable us to use our soil and water resources more fully for the maximum benefit of society.

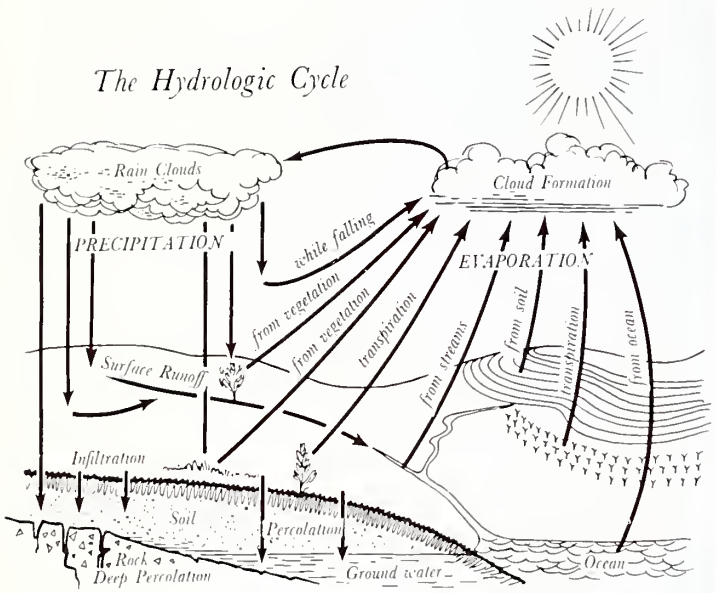
Wise use of soil and water requires a sound technical background. Agricultural research has resulted in a modern agricultural technology that enables one American farmer to produce sufficient food and fiber to meet the needs of more than 55 people. Knowledge gleaned from agricultural research is widely practiced in the field. As a result, the production efficiency in agriculture, our biggest industry, has skyrocketed.

On pages that follow are some of the current Corn Belt soil and water research activities by scientists and engineers of the Agricultural Research Service. These workers cooperate closely with their counterparts in the State agricultural experiment stations and universities.

The Corn Belt is one of the world's most important agricultural regions. It produces 88 percent of the Nation's corn, 74 percent of the soybeans, 60 percent of the wheat, 49 percent of the beef, 78 percent of the pork, and 48 percent of the milk. Forty-three percent of the total U.S. cash receipts from farming are derived in the Corn Belt States.

A. Runoff and Streamflow From Agricultural Watersheds

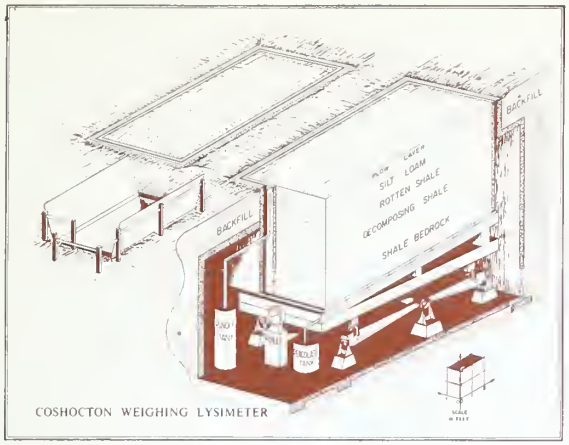
The primary objective of hydrologic research is to evaluate the response of agricultural watersheds to water. Watershed research can provide information to reduce flood damage, make appropriate use of the land, extend recreational and wildlife uses, develop municipal and industrial water supply, and improve drainage and irrigation practices.



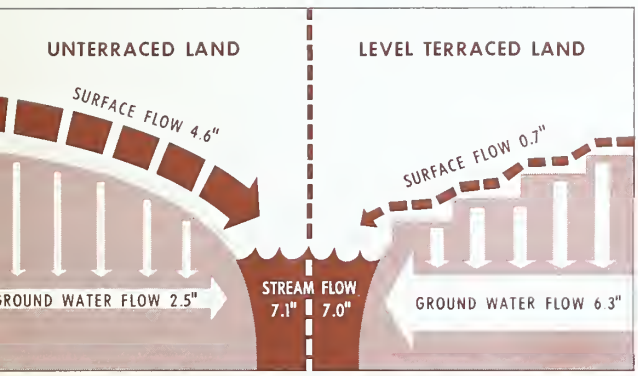
The hydrologic, or water cycle, is a continuous cycling of water from the ocean to the sky to the land and finally back to the ocean. Water is evaporated into the atmosphere from land and water surfaces, is lifted, and eventually is condensed and returned to the earth's surface as rain, hail, dew, snow, or sleet. How this precipitation occurs and its interaction with the land is of particular concern to man and agriculture.

A flash flood in east-central Ohio washed out the bridge and deposited it downstream. Precipitation measurements by hydrologists at the North Appalachian Experimental Watershed, Coshocton, Ohio, have shown a striking deviation from local severe-storm-precipitation design criteria used in highway and other constructions.

Local residents help with the precipitation measurements in eastern Ohio. This resident observes a small tube-type rain gage and mails storm rainfall data to scientists at Coshocton. Sixteen hundred resident volunteer observers in a 1,600-square-mile area assist in this study. Their data are correlated with those from a network of rain gages and with measurements by the U.S. National Weather Service at the Akron-Canton airport radar station to determine the intensity and distribution of local severe summer storms.



Lysimeters are isolated soil masses that have been instrumented to record weight changes and water percolation. The instruments enable scientists to make accurate assessments of moisture behavior in the soil. The lysimeter shown is 1/500 of an acre and 8 feet deep. It weighs 65 tons, yet can be weighed to a precision of 5 pounds. Scientists at Coshocton use lysimeters to study evapotranspiration, moisture use by crops, precipitation, water movement, and pollution.



Level terraces are an effective means of controlling erosion (see sections B & C), but what influence do they have on surface runoff and on ground water flow? Research conducted by scientists of the North Central Watershed Research Center near Council Bluffs, Iowa, has shown that the total water yield to streams is essentially unchanged. But much more of the water from the terraced area travels through the soil first. The values shown are 7-year averages for the research watersheds: rainfall was about the same. Filtering more of the water through the soil means that higher quality water enters the streams and that damaging flooding is greatly reduced.

The movement of water through soil and rock into the zone of saturation and the effect of land management practices on this movement are significant factors in hydrologic studies on agricultural land. Recorders are used to measure water-level fluctuations. Tape over wheel in foreground is connected to a float. Changes in water elevation are permanently recorded on chart. Later, the data on the charts are transferred to punch cards for computer analysis. This type of recorder is extensively used in soil and water research.

B. Sedimentation—Prediction and Control

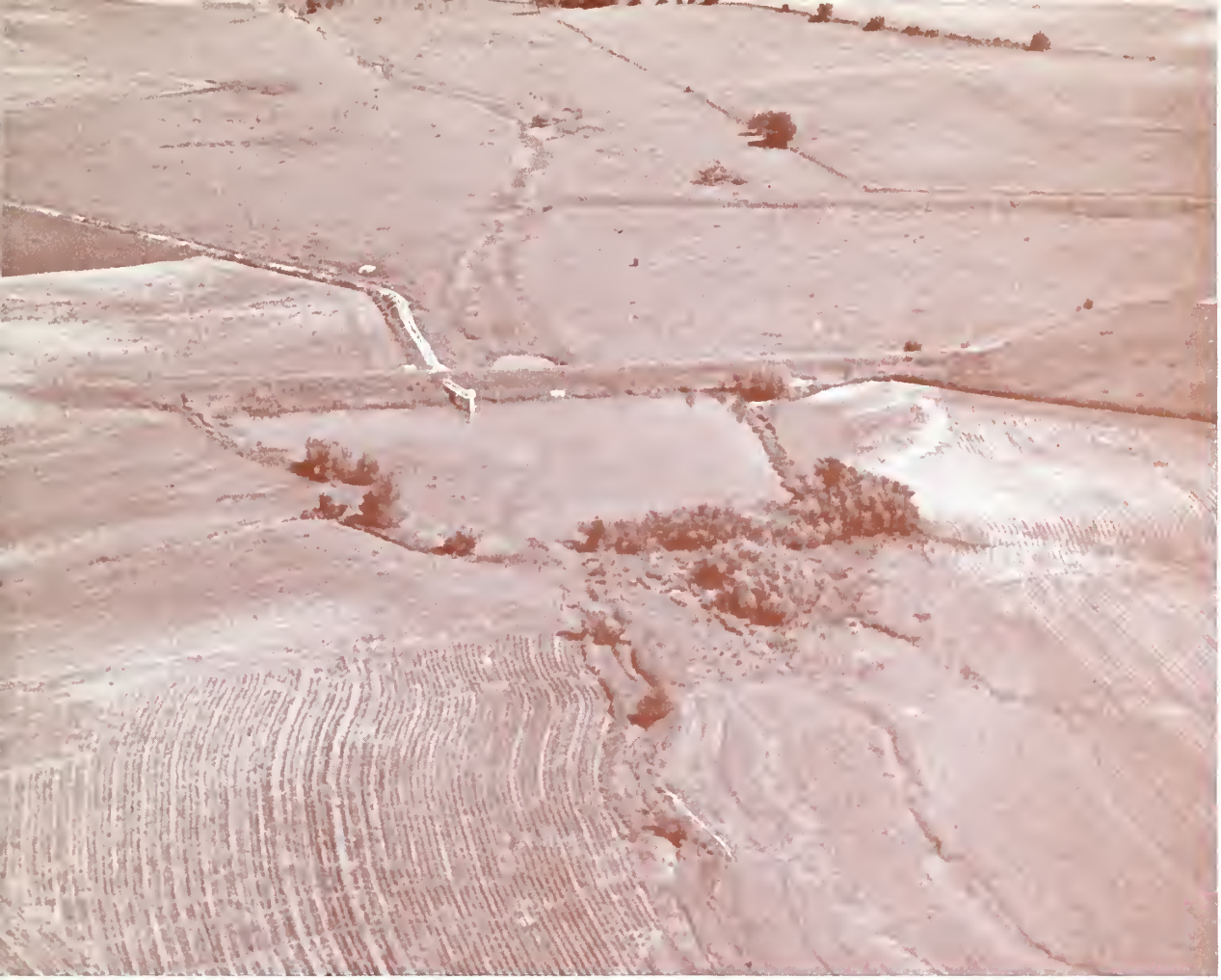
In the United States each year, about 4 billion tons of sediment are removed by runoff and streamflow. About one-eighth of this reaches the oceans. The remaining 3½ billion tons is deposited in uplands, flood plains, channel systems, and reservoirs. Reservoir depletion is a critical problem, especially in small reservoirs with capacities of 100 acre-feet or less. These are filling at an average annual rate greater than 3 percent per year.

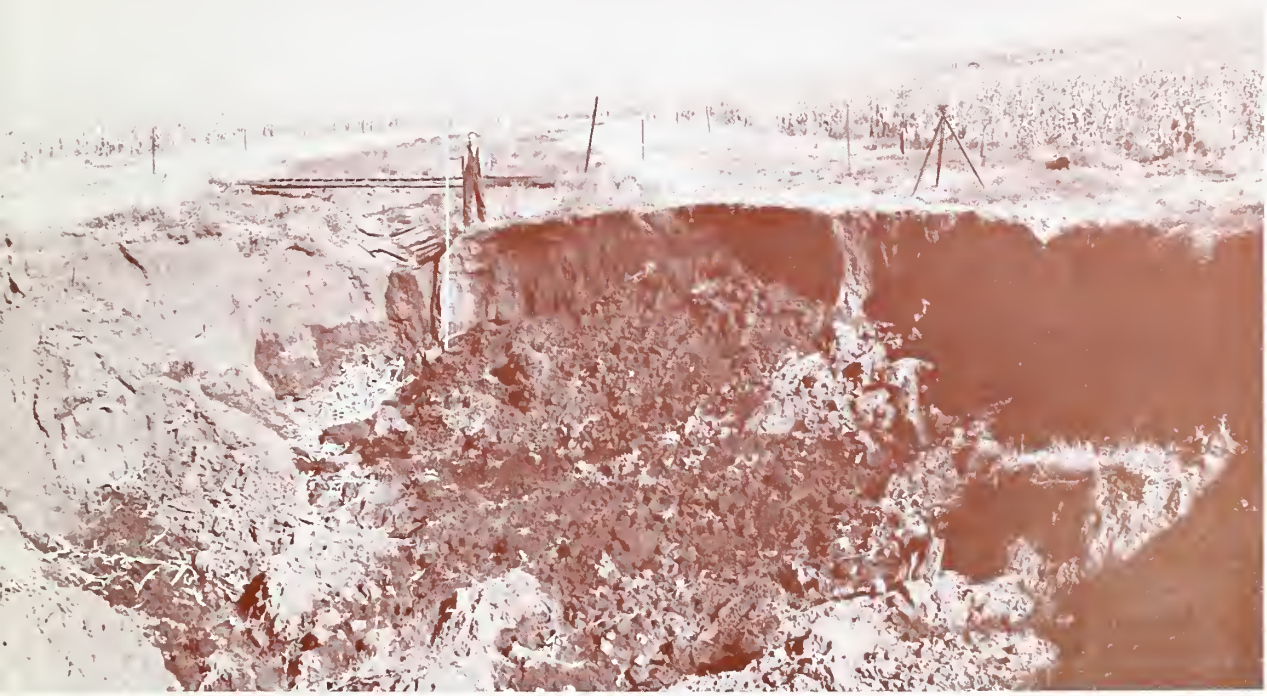
Sediment damages cropland, fills streams and reservoirs, and chokes our Nation's harbors. Small reservoirs are filled much more rapidly than their designers had planned. For example, this reservoir on Mule Creek in western Iowa was built in 1954 with a 50-year storage capacity. Yet, when this photograph was taken in 1957, the reservoir was completely filled with sediment.

Metal weirs have been installed just downstream from the gully head to monitor water runoff. Here a technician is collecting runoff samples, which will then be analyzed for sediment content and also for nutrients in associated pollution studies.

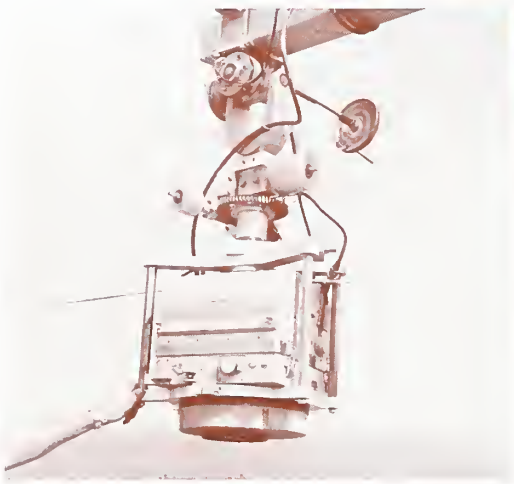
New soil and water management techniques are being evaluated at the North Appalachian Experimental Watershed. The no-tillage method, which consists of planting seed with minimum soil disturbance and killing the existing vegetation with a herbicide, has been most successful. No additional tillage operations are required. Corn may be planted either in a killed sod or in the residue of a previous row crop as shown here. The sod and crop residues cover the soil and protect it from raindrop impact and erosion. Corn yields from no-tillage watersheds have exceeded yields from conventionally tilled ones.

Where does sediment come from? Unprotected farm fields, rapidly eroding gullies, numerous building and highway construction sites, streambanks—all produce countless tons of sediment. Researchers at Council Bluffs, Iowa, have elaborately instrumented several watersheds to study sediment sources and yields and the mechanics of gully erosion. This shows a rapidly eroding research gully.





Grass-backslope terraces have been a recent development to control gully erosion in the Corn Belt Region. These are designed to allow the farmer to use large equipment more fully. Because these terraces are parallel, point rows are eliminated. The terraces shown were installed in 1963, the first in southwestern Iowa. They have functioned effectively, even in 1967, a year of excessive rainfall (SCS photo).

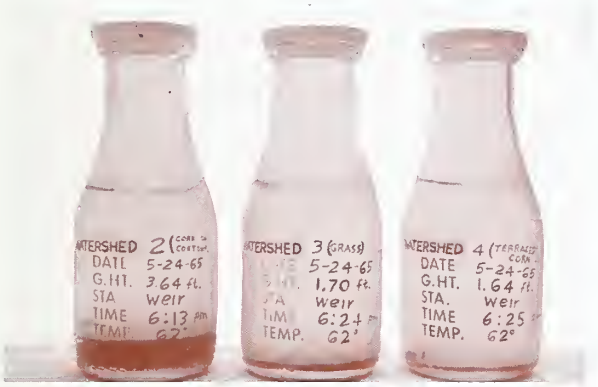


Measuring gully enlargement is difficult, especially because direct measurements would disturb the gully walls and influence the research results. Scientists at the North Central Watershed Research Center modified a surplus aerial photography camera for low-level photography. It is boom-mounted and is suspended over the gully (lower right). The shutter is actuated by remote control. Photographs obtained with the boom-mounted camera are analyzed on a stereo plotter. The resulting gully profile can be mapped to 0.1-foot contours without subjecting the gully to physical disturbance.

C. Improving Water- and Wind-Erosion Control

Unprecedented consumer demand for food and fiber has greatly increased the land devoted to crop production. Accelerated erosion may result. Erosion seriously reduces our nonrenewable topsoil resources and substantially increases the cost of farming.

Visual evidence that conservation pays is shown in streamflow samples. These were taken of research watersheds in soil erosion during a rainstorm on May 24, 1965. Sediment in the bottom of the bottles represents the concentration of sediment in runoff water during the time of maximum sediment movement. Rainfall amounts and intensities were uniform at all locations during this storm. The left sample is of runoff water from a field of corn planted on the contour; the center, from grassland; and the right, from corn planted on terraced land.



The distribution of sediment in reservoirs is important in studying reservoir trap efficiency (the ratio of sediment deposited to the total sediment entering a reservoir). Neutron-scattering techniques are used to measure the density of sediment deposited in a reservoir. A probe (near center of photograph) containing a radioactive source and a Geiger tube is lowered into the bottom sediment. Pulses from the Geiger tube are carried through the electrical cable and are counted with the scaler on the left boat. The larger tube takes samples of the sediment. Measurements are made on a coordinate system for accurate assay of the reservoir sedimentation processes.

Water erosion occurs in many forms. It may occur in conspicuous gullies as shown on page 9, or it may be in a much more subtle form of sheet and rill erosion on unprotected farmland as shown. Its end product—sediment—causes serious damage to flood plain land, reservoirs, navigation facilities, recreational sites, and aquatic environments. Water quality is impaired, thus making it less suitable and more costly for consumer uses.

Photograph of the splash patterns for a 5.6-mm-diameter drop striking a smooth surface covered 0.5-mm deep with water. This technique enables researchers to describe mathematically the initial stages of the erosion process.

The interaction of raindrops with the soil surface is an important constituent of the erosion process. At the North Central Soil Conservation Research Center, a 16-mm movie camera, capable of speeds from 150 to 8,000 frames per second, records raindrop impact. Water drops released from a tower 40 feet high strike the plate-glass target table near the engineer's elbow.

At Lafayette, Ind., ARS scientists use laboratory models to study detachment and transport factors of soil erosion. Their model allows rapid determinations of the influences of slope steepness and length, soil-cover conditions, and other factors in soil erosion. Time-lapse movies of this small glass-bead model provide an interesting vision of the erosion process.

Runoff and erosion measurements have been obtained for many years from runoff plots, like these at Kingdom City, Mo. At the ARS soil-loss data center in Lafayette, Ind., more than 11,000 plot-years of data from 48 stations in 26 States have been evaluated. Statistical techniques and digital computers provided the tools to derive the Universal Erosion Equation that is widely used to design erosion-control and water-conservation measures on a particular farm, watershed, or construction site.

Erosion—both checked and unchecked—is in evidence on this aerial photograph of two soil and water conservation research watersheds near Council Bluffs, Iowa. This photograph was taken on June 22, 1967, after 22 inches of rainfall during the preceding 22 days. Four watersheds have been instrumented to determine factors affecting gully growth and the effect of level terracing on gully growth, sediment yield, and water yield. The watershed in the upper right has been level terraced (grass backslopes) and kept in continuous corn. That on the upper left is a continuous-grass watershed. The remaining two (not shown) are in continuous corn planted on the contour. Note the extensive rill erosion from the soybean field (nonexperimental) at the lower left. The grass-backslope terraces retained the rainfall and prevented erosion.

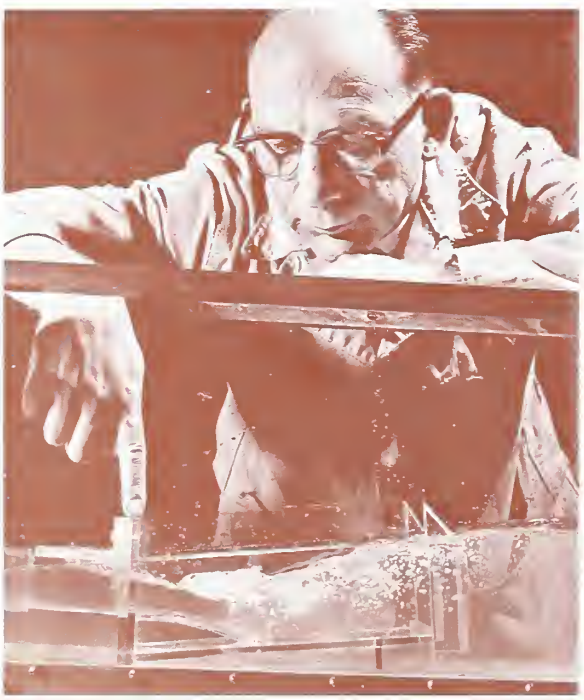
Wind erosion is a dominant problem on some 55 million acres of cropland in the United States. It ruins farmland, pollutes the air, damages plants, blocks highways and causes accidents, and causes undesirable sand drifts around homes and buildings. These greenbeans were subjected to varying degrees of abrasion from wind erosion. Abrasion upsets nitrogen metabolism, reduces yield, and kills plants if the speed and quantity of eroded materials are sufficiently great.

ARS research scientists at Manhattan, Kans., have employed portable field wind tunnels to evaluate the effects of cloddiness, roughness, and vegetative cover on wind erosion. In this picture, a wind tunnel is being used to evaluate the effect of feedlot wastes for wind erosion control. Their studies have culminated in a functional wind erosion equation that is used widely to compute soil losses and to describe the wind erosion process.

Conservation tillage provides a practical method of effecting a good wind erosion control program. It effectively maintains a land cover of crop residues, produces stable clods or aggregates on the land surface, and roughens the land surface. Shown is one form of minimum tillage: a rotary till-planter. Intensive tillage of the row area only conserves crop residues yet provides an adequate seed environment for the new crop.

D. Structures for Water Control and Measurement

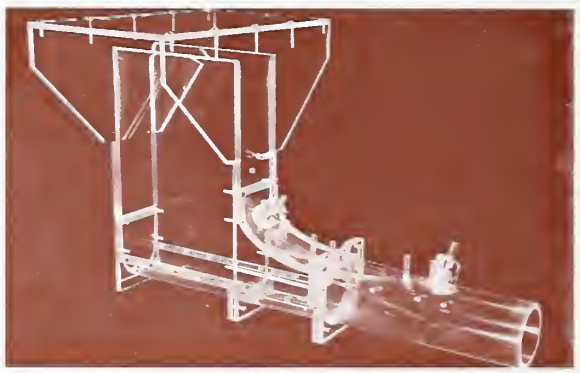
Effective, dependable, and economical engineering structures for controlling and measuring water are essential elements for sound soil and water conservation practices. At the St. Anthony Falls (SAF) Hydraulic Laboratory, University of Minnesota, a team of ARS engineers is developing generalized designs for the thousands of watershed protection, flood prevention, water conservation, grade stabilization, erosion control, irrigation, municipal water supply, and multiple-use structures. These are being built throughout the United States by the Soil Conservation Service (SCS) and their cooperators under Public Laws 46 and 566.



Much of the research conducted by this ARS team has employed small-scale models of larger structures. Illustrated is a water model of the SAF stilling basin. This type of basin has been widely used in conservation, highway, and other construction.

Hood inlet, which, because it assures full-capacity flow, permitted designers to substitute a 72-inch-diameter culvert for two 108-inch-diameter culverts with sharp-edged entrances specified in the original highway design.

This transparent plastic model was used to develop improved designs for elbows and transitions between a two-way drop inlet and the spillway barrel. The new elbows and transitions guide the water smoothly into the barrel and reduce the possibility that the high-velocity water will damage the spillway by causing cavitation.

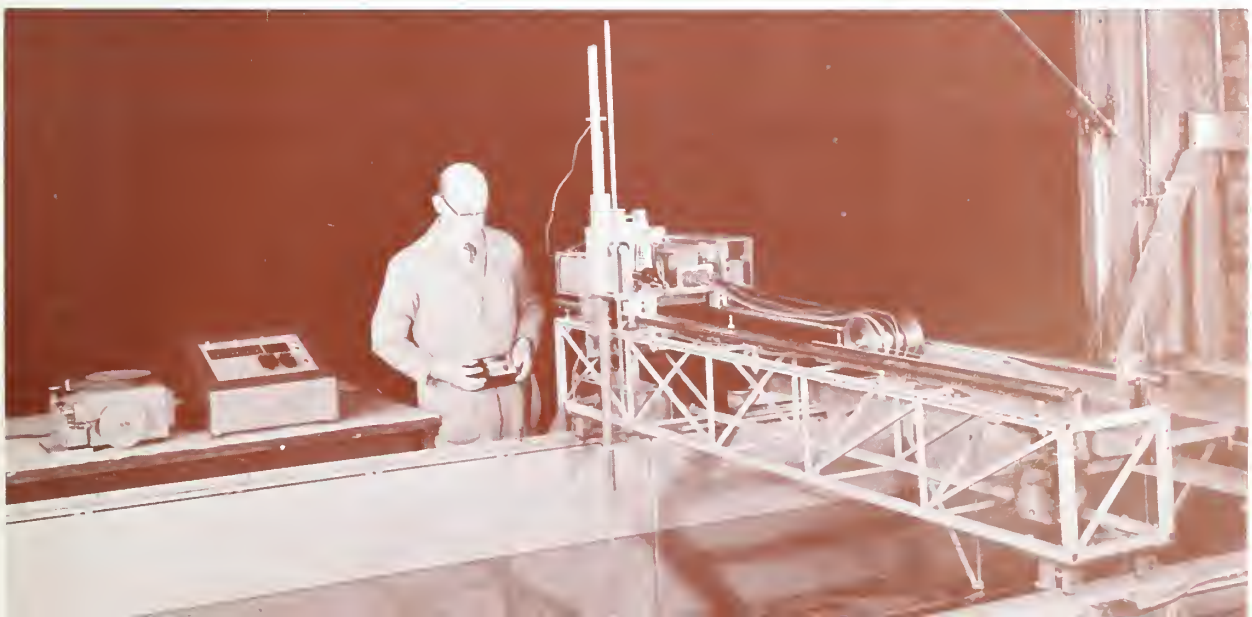


In some instances, air has been substituted for water to simplify the laboratory testing. The air apparatus shown determines flow characteristics in a two-way drop inlet model.

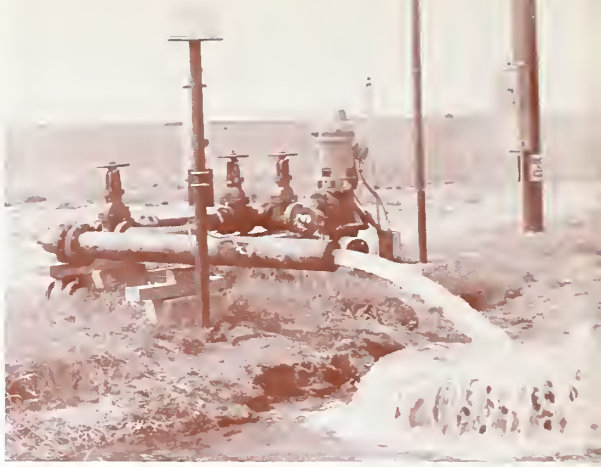
An SAF stilling basin at the exit effectively and economically prevents erosion of the bank and streambed. SAF stilling basins have been applied worldwide.

The Soil Conservation Service and others are installing many hundreds of cantilevered spillway and culvert outlets annually. Although the design of the outlet itself is well understood, the resulting scour hole is not. The study will develop information for the design of plunge-pool energy dissipaters.
Severe damage to expensive riprap by stormflow from a principal spillway outlet in West Virginia. (SCS photo).

The ARS team at the St. Anthony Falls Hydraulic Laboratory has developed a highly automated model to study the scour at cantilevered outlets. The model, which represents highly sophisticated developments in measurement techniques, is capable of measuring and relaying to a computer the precise size and shape of a scour hole. The size of the hole scoured in various soils will determine the size of the preshaped plunge pool to be used.



E. Increasing and Conserving Farm Water Supplies



In the humid area, average annual rainfall exceeds the needs for crop production. Yet, poor rainfall distribution causes severe crop loss from lack of water when critical crop-growth periods coincide with seasonal droughts or during occasional severe drought years. These conditions have focused attention on the total farm-water management; soil-water supplies in the root zone; the capture, storage, and beneficial use of water normally lost from a watershed through surface runoff and interflow; and the restoration of depleted underground aquifers for use at a later time.

Conservation practices installed during the early conservation movement failed to take into account the great increase in power that would become available to the farmer. Consequently, many of the terraces installed during the thirties and forties are not rowcropped today because their design included point rows and other features that do not accommodate the large farm machines of today. When unimproved sloping land is rowcropped, excessive soil and water losses usually result. ARS researchers at Ames, Iowa, are developing economically feasible soil and water management systems that will provide nearly total control and use of soil and water resources. Slopes are landformed to a grassed-backslope terrace system that conveys excess water through a tile drainage system to reservoirs. These reservoirs are then used to supply irrigation water back to the land during low-rainfall periods. The terraces are parallel and designed to accommodate today's large farm machines, and point rows and other objections are overcome. The conservation practice is more acceptable to the farm operator. Hence, society benefits through cleaner water and improved recreational opportunities.

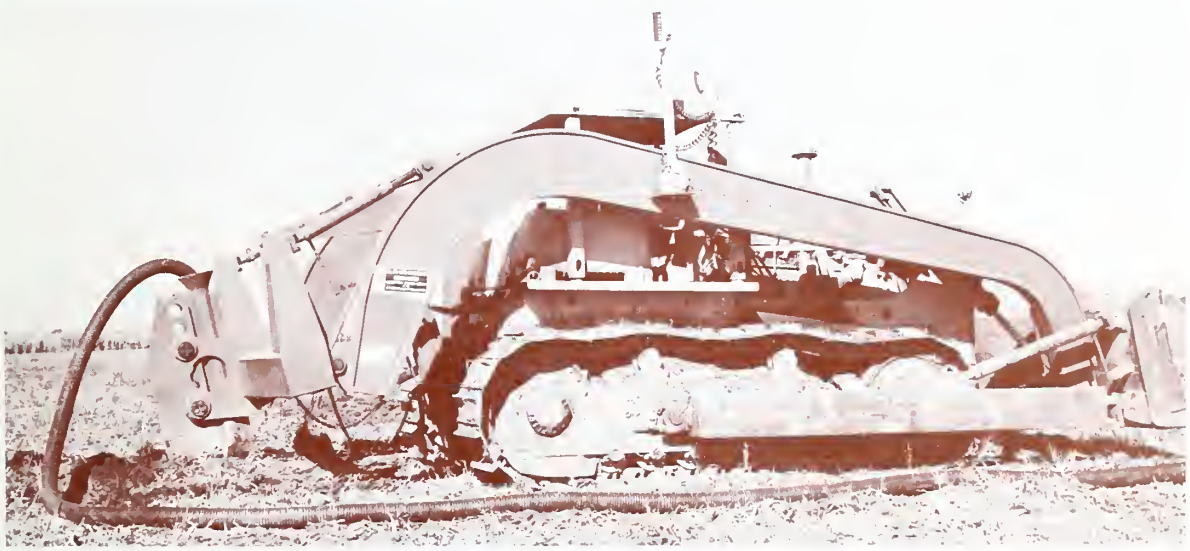
Nearly 400,000 acres of agricultural land in the Red River Valley of North Dakota have saline water tables that hamper crop production. Scientists from the Northern Great Plains Research Center, Mandan, N. Dak., determined that artesian pressure in an underlying sandstone aquifer causes upward waterflow that brings salts to the crop root zone. Pumping from the aquifer to reduce the artesian pressure stops the upward flow of saline water and causes the water table to reestablish at a lower level. Rainfall then can infiltrate into the soil and remove salt from the root zone.

Field-drainage studies, such as the tile- and surface-drainage experiment near Castalia, Ohio, enable scientists to measure directly in crop and hydrologic response the effects of various drainage treatments. The undrained plot is near the center of the picture. Nutrient losses in drain tile effluent and how drainage affects trafficability and timeliness of tillage operations are also being evaluated. In this study, ARS scientists participate with researchers from the Ohio Agricultural Research and Development Center.

F. Improved Drainage and Irrigation Systems for Agricultural Lands

Drainage research is directed toward improving lands for growing crops, reducing the probability of crop failure, and increasing the efficiency of farming operations. Drainage is important to Corn Belt soils. Seventy-nine percent of the tile drains installed in the United States in fiscal year 1972 were installed in the North Central States.

ARS engineers at Columbus, Ohio, have been instrumental in the development of new drainage materials and methods for installing them. The plow-in drainage machine shown here can install up to 6-inch-diameter corrugated plastic drainpipe as much as 6 feet deep. The machine employs a floating-beam mole plow for opening the drainage channel. Plastic pipe is fed down the shank and lines the channel formed by the mole. Laborious trenching and back-filling are not required with the system, and plastic pipe is easy to transport, highly durable, and may reduce the cost of farm drainage.



High-speed installation of drainpipe requires an automatic grade-control mechanism. The laser, a development of space-age technology, automatically controls drain depth and grade on the high-speed drainage machine. The fan-shaped laser beam is projected across the field, where a photo-tube detector (visible slightly above tractor cab) on the drainage machine senses the beam and provides electronic impulses to the hydraulic cylinders on the tractor. Proper depth and grade on irregular ground surfaces is automatically maintained by raising or lowering the plow-hitch point, which is on the rear of the dozer blade. Several machines can be operated from one laser unit.

G. Soil and Water Pollution from Fertilizers, Agricultural Chemicals, Animal Wastes, and Other Sources

Agriculture's primary concern is the maintenance of an adequate food and fiber production to meet both domestic and foreign needs. To meet these needs and to maximize the efficiency of crop production, farmers have maintained the nutrient status of the soil through the use of commercial fertilizers and have employed herbicides and pesticides in their never-ending battle against weeds and insects. Livestock feeding operations have become greatly intensified resulting in large concentrations of animal wastes. Metropolitan areas are seeking methods to dispose of municipal wastes. Research is underway at several locations to evaluate methods to utilize these wastes as plant nutrients and to determine the degree of ground and surface water enrichment from such land applications.

At Coshocton, Ohio, in a highly automated study of the relation of agricultural practices to the pollution of surface and subsurface water with chlorinated insecticides and other agricultural chemicals, dieldrin has been applied to a test watershed. Shown in the foreground is a flume for measuring the quantity of runoff and a slot sampler for sampling the runoff. At the upper right are controls for obtaining representative samples of the runoff for chemical analysis and a refrigerator for storing the samples before chemical analysis. Soils, crops, air, runoff, and deep percolation are sampled for agricultural chemicals.

Chemicals contained in runoff from agricultural land have often been cited as a primary source of excess nutrients in lakes and streams, and hence, a primary cause of eutrophication. Scientists at the North Central Soil Conservation Research Center have instrumented runoff plots at several locations in Minnesota to measure dissolved nutrients in runoff water from farmland, forest, and native grass prairie.

Nutrients in runoff from forested upland areas are being measured in cooperation with the U.S. Forest Service at Grand Rapids, Minn.

Although cropland is often accused of greatly amplifying eutrophication, the runoff from this fertilized corn plot in western Minnesota contains only slightly more dissolved nitrogen than that from the forested plot (upper right) and about the same amount of dissolved phosphorus as the forested and prairiegrass plots. The research is providing information about man's influence on his environment.

Native grasses are not usually associated with the pollution of our lakes and streams. Yet, the runoff from a native-grass prairie plot in Western Minnesota contained significant amounts of dissolved nitrogen and phosphorus. Most of the dissolved nutrients were carried in the spring snowmelt runoff, after freezing and drying processes had destroyed the previous year's plant materials.

Feedlots are a potential source of pollutants, particularly phosphates and nitrates. At Lincoln, Neb., a portable rotating-boom rainfall simulator produces a high-intensity storm on a sloping feedlot. Rainfall simulators have played an important role in erosion, animal waste, and other research because scientists do not depend upon the highly variable natural rainfall to conduct their research.

Scientists at Lincoln, Neb., have extensively studied the movement of potential pollutants from feedlots. Odors, and the nitrogen compounds associated with them, are being studied at this feedlot near Central City, Neb. The weak acid traps located on the fence in the foreground extract odor related materials for subsequent qualitative and quantitative analysis. In addition to the air traps, two caissons have been installed to provide access for monitoring pollutant movement into and through the soil below the feedlot. Feedlot management is crucial if pollution is to be avoided.

Strip-mining coal, vital in meeting the Nation's energy needs, is practiced extensively throughout the North Central United States. However, reclaiming strip-mined land is a critical problem from both a water-quality and a crop-production viewpoint. Researchers at Mandan, N. Dak., have found that spoil piles are extremely phosphorus deficient and are frequently high in sodium and montmorillonitic clay (conditions generally unique to the Northern Great Plains strip mines). This essentially renders these spoils impermeable and highly erosive. Addition of P-fertilizers, straw mulches, and gypsum or sulfur amendments aid reclamation. Returning topsoil, however, has been most beneficial in reclamation.

In man's quest for a quality environment, he has decided that streams and rivers are no longer acceptable receptors of the wastes from his sewage treatment plants. He is looking for viable alternative methods of disposal. Because sewage wastes contain valuable plant nutrients, disposal on agricultural lands where the nutrients can be used by crops has been suggested.

Scientists at St. Paul, Minn., are conducting extensive studies of the influence of sewage wastes on soils, plants, water, and the environment. This photograph shows an experiment on a sandy soil where up to 200 tons of dry sewage sludge were rototilled into the topsoil.

The experiment tested yield response and heavy metal uptake for 10 vegetable crops. Plants responded favorably to sludge application (increasing from left to right in the photograph). Analysis of edible tissues of the vegetables grown the first year on heavy sludge-amended soils indicated no dangerous metal uptake; however, further study is necessary to assess how decomposition of the sludge or how additional sludge applications will influence metal uptake.

Two new studies on the safe disposal of sludge and waste-water have recently begun. These studies utilize watershed-sized research areas where complete runoff control is employed to eliminate any possible stream contamination.

The watersheds in western Iowa that are being used for gully and terrace research (see sections B and C) are also being used to study pollution from chemical fertilizers. Up to 2½ times the recommended fertilizer rates have been applied to cornland—yet nitrogen and phosphorus discharged in surface runoff and base flow has been low. The terraces control runoff and erosion, and the soil serves as an effective filter. The ground water is sampled by lowering the small tube-shaped bucket down the pipe-encased well.

Scientists observe conversion of liquid fraction in studies of micro-organisms in feedlot waste; center jar holds an odor-free portion of the same liquid after fungal micro-organisms had consumed most of the chemical oxygen demand, rendering it fit for crop irrigation. Top jar contains fungal micro-organisms recovered from fermented liquid waste; scientists are hopeful that this will be suitable as a component in animal feed.

Today's pollutants may become tomorrow's products. Such conversions of animal wastes are the goal of research at the Northern Regional Research Center, Peoria, Ill. Feedlot waste is inoculated with the fungus, *Trichoderma viride*, that grows on the fermenting feedlot waste producing protein and enzymes.

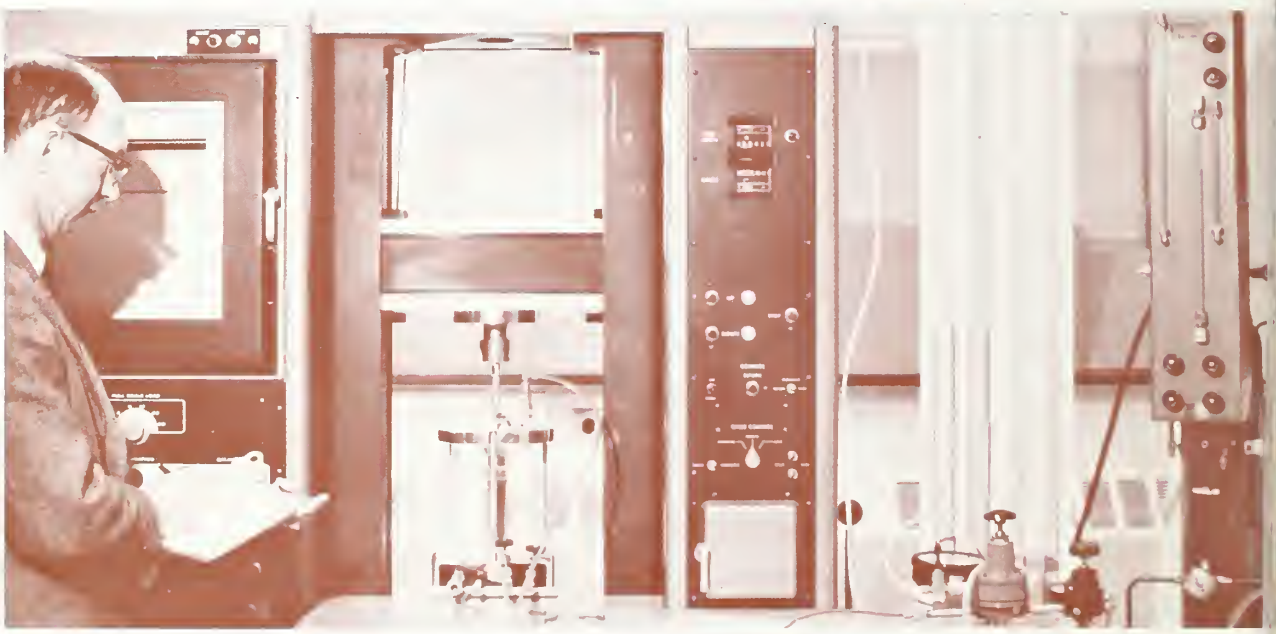
Fiberboard has been produced from residue fractions of feedlot waste. A small hydraulic pilot press is used to manufacture the fiberboard. Methane gas is also a product of the same fungal decomposition process.

H. Improving Soil Tillage and Structure

Tillage is a major production cost on most soils in the Corn Belt. It has a major influence not only on crop production, but also on the management of water resources. Thus, it has marked effects on the quality of the environment.

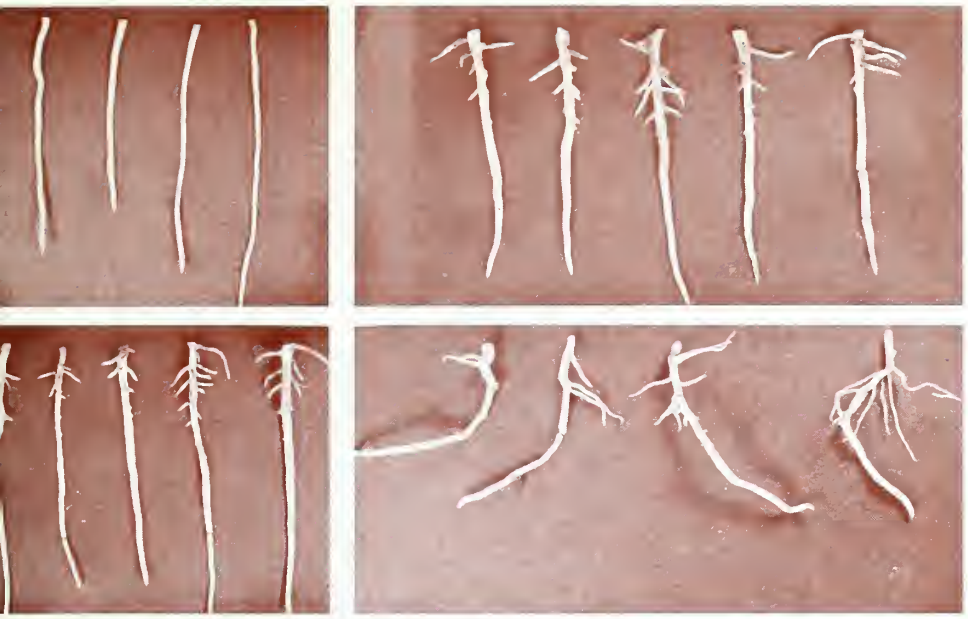
On most soils in the Corn Belt, the seedbed preparation is begun in the fall and is completed in the spring. The soil surface left unprotected throughout much of the year can result in excessive runoff and erosion during late spring. Research is directed toward better methods of evaluating soil structure-soil water relations. It is likely that the number of tillage operations can be reduced without reducing crop yields; petroleum consumption can be significantly reduced. Proper management of soil and water resources can result in both an ample food supply and a highly desirable environment.

Scientists at St. Paul, Minn., use elaborate measurement techniques to assess soil-structure formation and characterization. A scientist prepares a sample for analysis in a visible ultraviolet spectrophotometer. Objectives of this research include measuring soil particle bonding.

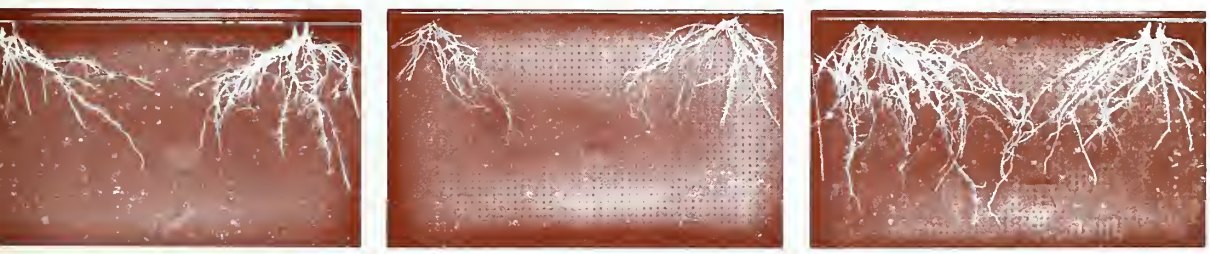


A universal testing machine measures precisely the compressive and tensile strengths of soils and clay films. By knowing more about soil strength, scientists may assess or predict the fracture processes resulting from tillage operations.

Understanding the factors that influence root-growth changes and the development of suitable mechanical-probe measurements may make it possible to predict the influence of various agronomic practices on root growth, crop yields, and longtime effects on soil physical conditions.



Root growth is often severely retarded by high soil strength and low porosity. At the North Central Soil Conservation Research Center, peas were grown in remolded clay soil. After about 100 hours of growth, roots were exposed and photographed. As the soil density increased root elongation decreased, the roots became twisted and malformed, and more lateral roots developed.



These three photographs were taken 39 days after corn planting, and they illustrate the influence of mulch on corn root growth. From left to right the treatments were: No straw mulch, 20-inch-wide straw-mulch strip centered over the row, and a 20-inch-wide straw-mulch strip centered midway between the rows. Straw mulch over the row reduced root growth; mulch between the rows enhanced root growth. White lines on the right and bottom are spaced about 2 inches apart.

The crop itself often can be used as an indicator of the effect of various tillage practices. This photograph shows a root-sampling frame, developed jointly by researchers from the Minnesota Agricultural Experiment Station and ARS. It is capable of extracting a soil-plant sample 60 by 36 by 12 inches. These soil samples (monoliths) are taken to the laboratory, where the soil is carefully washed away and the plant roots are then photographed. This root extraction technique is also being used at Ames, Iowa, in studies of tillage traffic patterns on root growth.

I. Efficient Water Use and Maintaining Soil Fertility on Nonirrigated Land

In the western and northern parts of the Corn Belt, rainfall limits the growth of corn and other crops. Managing the erratic water supplies of drylands is difficult; yields and quality of crops are often low, and farming operations may be delayed. In some of these same areas, soil salinity of natural origin is also a problem.

Even though fertilizer has played an important role in agriculture's tremendous productivity increase, maintenance of soil fertility by fertilization is still largely an art because of the complexities of the soil-water-plant system and the great diversities in soils, climate, and plants.

Research on methods of more efficiently conserving water is a prime objective of much of the work at the Northern Great Plains Research Center, Mandan, N. Dak. Various methods and time of tillage, use of mulches, landforming, and related activities have been or are being evaluated as water-conserving practices. A promising method is shown in which strips of stubble are left standing over winter to act as a snow barrier. Research data indicate that more snow can be trapped and held on the field by using stubble strips than could be accomplished had the entire field been left in standing stubble. With proper management, the extra snowpack can be translated into additional soil-water-storage and increased crop yield under dryland.

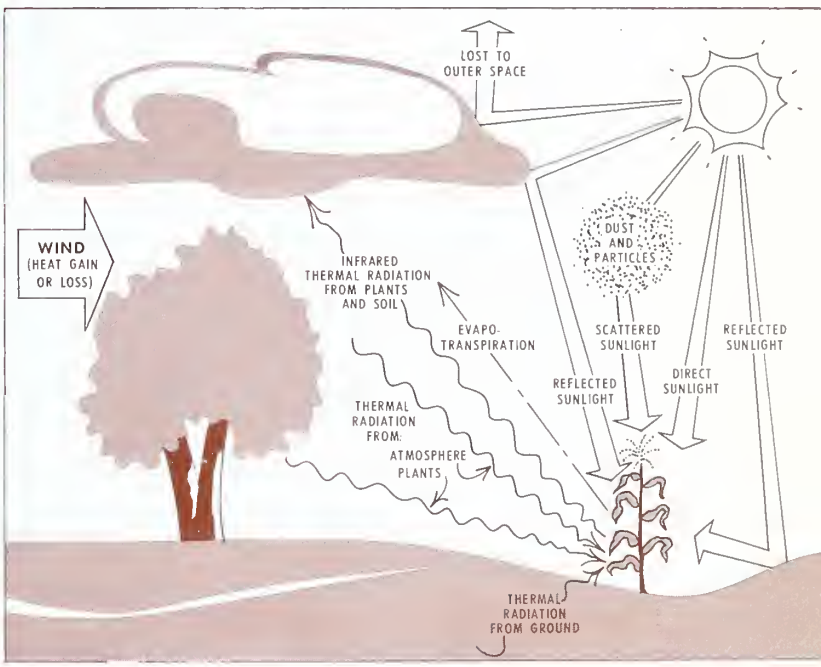
Research at Mandan, N. Dak., illustrates the influence of N fertilization and irrigation (left center). The small pipe, covered with a tin can (right center) is an access tube for a nuclear moisture meter. Lack of adequate available nitrogen in the soil may be equally as restricting as lack of water. Additional water without added N is of little benefit and added N is of limited benefit when water is severely restricted. Because cool-season grasses produce most of their dry matter early in the season when temperatures are lower, a slow rate of mineralization of soil N may result in restricted production without N fertilization.

Atomic and nuclear science has found extensive application in soil and water research. Shown is a nuclear soil-moisture meter. The soil probe at the right consists of two concentric cylinders. A larger cylinder that serves as the safety shield, and a smaller cylinder (or probe) containing both a source of neutrons and a Geiger tube which is lowered into the soil through a metal access tube. Neutrons emitted by the neutron source pass through the tubing and collide with the large hydrogen atoms of the water molecules in the soil. As a result of this collision, the fast neutrons lose speed and become slow neutrons. These slow neutrons then strike the Geiger tube which emits an electrical impulse that is conveyed through the cable to the scaler in the cart. Hence, the scaler reading indicates the amount of moisture in the soil.

J. Energy Use in the Soil-Plant-Atmosphere Continuum

About 20 million acres of Solonetzic soils exist in the Northern Great Plains. These soils, locally known as "scab-spots, gumbo soils, or claypan soils" contain a genetic B-horizon relatively high in sodium affected montmorillonitic clay. This condition results in extremely low infiltration and poor crop yields. Frequently, naturally occurring calcium carbonate and gypsum amendments, often prescribed for rectifying the problem, are found below this B-horizon. Therefore, plowing deep enough to penetrate the B-horizon not only disrupts the claypan but also mixes gypsum and calcium carbonate with the sodium-affected clay. Calcium then replaces sodium on the soil exchange complex, and the displaced sodium can be leached below the root zone. Deep plowing (24 inches) at Mandan has resulted in a 10-bushel increase in yields of wheat grown in rotation with fallow for 7 years after plowing.

Research to understand the mechanisms controlling the whole soil-plant-atmosphere continuum is an approach to finding ways to manipulate the environment and the plant to man's advantage. This research strives for better understanding of the mechanism by which energy and mass at the earth's surface are transported from one part of the soil-plant-atmosphere system to another.



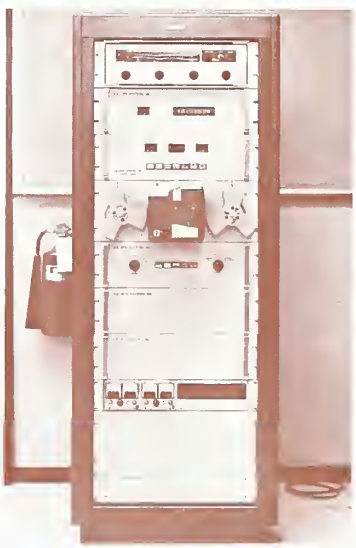
Outside the earth's atmosphere the sun delivers about two calories per square centimeter per minute of solar radiation to a surface directly facing it. This energy is transported to and away from the plant by means of highly complex exchange mechanisms. The rates at which they proceed are highly variable and dependent on factors that generally are neither well defined nor easily measured.

In an Illinois study, ARS scientists cooperated with University of Illinois researchers to determine the primary ecological factor limiting corn yields at high productivity levels. Sunlight had been postulated as the limiting factor. To evaluate this postulate, large aluminum reflectors were placed in the corn rows to provide a light-rich environment for the lower corn leaves. Grain yields per plant increased as much as 26 percent in the light-enriched environment. Although using reflectors may not be practical in corn production, the study did show that light was the primary ecological factor limiting potential corn grain yields. This information may be useful in the development of new varieties and management systems.

How the plant performs in its natural environment—that is, its three basic life processes of photosynthesis, respiration, and evaporation—is of fundamental concern in research at Urbana, Ill. These processes are assessed from measurements of the carbon dioxide and water vapor changes in the immediate crop environment enclosed by the plastic canopy. The canopies are mounted on a track and contain a programable control system that enables them to move over a field plot, close the canopy ends, measure relative humidity, extract gas samples for CO_2 analysis through the tube in the foreground, raise the doors, and propell themselves to the next plot where the whole process is repeated.

Gas samples are carried to an infrared analyzer and data recorder in a nearby instrument trailer. The rate at which plants use CO_2 in the daytime gives the plant photosynthetic rate, and the rate they give off CO_2 at night gives the nighttime respiration rate. An Eppley pyrhelimeter to measure solar radiation is located on the mast in the background. This system, called REP for respiration, evaporation, and photosynthesis, enables researchers to discover the basic factors of plant life processes, and it will provide the means to study varietal response on different soil, water, and fertilizer management systems. Although wheat is shown in these photographs, major emphasis has been on soybeans; other crops may be studied.

Field research at Morris, Minn., has shown that simple modifications of the soybean environment can increase bean yield and, hence, the efficiency with which soybeans use water. Planting two rows of corn for each 14 rows of soybeans increased soybean yields and net yields (corn windbreak plus the soybeans) about 10 percent. Total water use remained the same, hence, water-use efficiency was improved through the higher yields.



Elaborate micrometeorological measurements, obtained from heat, moisture, and radiation sensors (upper left), are collected on the automatic data-acquisition system shown. A digital computer then processes and analyzes the data.

This publication refers to research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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